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A Comparison of Cheese Yields Produced from Normal and Abnormal Milk

Raymond L. Rennich

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A COMPARISON OF CHEESE YIELDS PRODUCED FROM NORMAL AND ABNORMAL MILK

BY

RAYMOND L. RENNICH

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FROM NORMAL AND ABNORMAL MILK

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor   Date

Head, Dairy Science Department   Date

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INTRODUCTION

Mastitis has long been a problem to the Dairy Industry. All milk constituents are affected. Abnormal milk usually has a slightly higher total nitrogen and a lower casein content than does normal milk. Since the percent casein is believed to have the greatest influence on the yield of cheese, it is postulated that a lower casein content in milk will produce a proportionately smaller amount of cheese for a given volume of milk.

Cheese factories presently buy milk on the basis of fat percentage and weight with no regard to the amount of total protein or casein present. Therefore, it would be advantageous for the cheese factories to encourage the producers to produce a good quality milk, free from mastitis.

Most of the early work done in the field of mastitis has dealt with the detection or control of the disease. In recent years more of the work has been centered on the effect of mastitis on the composition of milk.

The objective of this study was to determine the effect of mastitis on the yield of cheese by actually making cheese by the regular procedure. Since very little work has been done in this area, the investigation was designed to analyze the milk, the cheese, and the whey.

REVIEW OF LITERATURE

In 1967 more than seventeen billion pounds of milk were used for cheese production in the United States. This accounted for 14.2% of the total milk supply. With the increased use of milk for cheese production it is essential to produce a high quality cheese at the lowest possible cost. In order to do this the factors that affect milk composition must be studied. One of the biggest problems to the Dairy Industry is the effect of mastitis on the composition and quality of the milk produced. Mastitis has been shown to affect almost all milk constituents (1, 2, 3). This study will review the degree that mastitis affects the various milk constituents.

According to Ashworth et al. (3) it appeared that damaged udder tissue does not retain its ability to synthesize the major milk components: casein, lactose, and fat; therefore, these constituents are affected. The permeability of the glands is affected, allowing blood proteins and salts to pass into the milk. With the increase in blood proteins and salts, the pH of the milk approaches that of blood. The chlorides and the whey proteins increase with an increase in mastitis reaction.

In the same study the relationship between the California mastitis test (CMT) and the solids-not-fat (SNF) and total solids (TS) content was compared. The CMT is a test for mastitis based on the number of leucocytes present in the milk. The reaction to the test is rated trace, one, two, and three. Samples of milk that varied from negative in the normal sample and trace in the abnormal to samples of negative in the normal to a CMT of three in the abnormal samples were examined. In all of the comparisons, the sample with the higher CMT reaction had less solids-not-fat and total solids when compared to opposite quarters from the same cow. The average difference varied from 0.12% TS for the negative-trace comparison to 1.07% for the negative-three comparison. When negative left quarters were compared with negative right quarters the difference was 0.02% TS. This difference was not significant. The SNF values in the same trial varied from 0.02% in the negative-trace to 0.58% in the negative-three comparison. When the negative left quarter was compared to the negative right quarter the difference was only 0.03%. This difference was not significant.

A consistent inverse relationship was found by Ashworth and Blosser (2) between the level of CMT reaction and the total solids and solids-not-fat content from opposite quarters. The greatest average difference was found between CMT negative and CMT three reacting quarters. The results varied from 1.02% on the total solids to 0.53% on the solids-not-fat.

Ashworth *et al.* (3) also studied the relationship between the CMT reaction and the fat content from opposite quarters. Their results ranged from an average difference of 0.09% on the negative-trace reaction to 0.45% on the negative-three reaction. The negative-two comparison showed a difference of 0.22% and was significant at P=0.05. All of the other comparisons were highly significant. The Ashworth and Blosser (2) study found an inverse relationship between the CMT reaction and the fat content from opposite quarters.

The protein portion of the milk was affected by mastitis in a different way than was the fat, total solids and solids-not-fat. Total protein, as measured by the dye binding method, was not highly correlated with the extent of mastitis as measured by the CMT reaction. Ashworth (1) compared the relationship between the CMT reaction and the protein content from opposite quarters. The results ranged from 0.03% difference in the negative-one comparison to 0.13% difference in the one-three comparison.

In other work done by Ashworth *et al*. (3) it was reported that there was an increase in the total protein for more severe CMT reactions. The increase was believed to be due to a seepage of the serum protein into the milk through the damaged udder tissue.

Ashworth (1) also compared the relationship between the CMT reaction and the percent casein in the milk. The percent casein of the total protein varied only 2% in the trace-one comparison, while it varied 5.9% in the trace-two comparison. The percent casein protein decreased while that of non-casein protein increased resulting in no changes in total protein percentage of the milk. The increase in non-casein protein was due to the presence of blood proteins in the milk. Studies by Bortree *et al*. (4) showed an increase in serum albumin and immune globulin after mastitis was introduced into the cows. Before inoculation, serum albumin and immune globulins constituted about 27 to 35% of the total whey protein. After inoculation these two fractions had increased to about 50% of the total.

Electrophoretic analyses by Lecce and Legates (11) of the whey proteins from the normal and the mastitic quarters showed that the whey protein fraction of the normal milk was much different from that of the abnormal milk. The most outstanding change in the mastitic quarter was an appearance of a fraction migrating at the rate of blood-serum albumin. This indicated an increase in the serum proteins in abnormal milk.

Kisza and Sobina (10) also worked with the proteins in normal and abnormal milk. They reported that the ratio of non-protein nitrogen to total nitrogen was not significantly different. The whey protein content of milk from cows with acute mastitis was about 2.5% as compared with 0.9% for chronic cases.

In other studies by Ashworth _et al_. (3) the relationship of the CMT reaction with the lactose level of milk was compared. Their results ranged from 0.05% difference in the negative-trace comparison to 0.77% in the negative-three comparison. All the comparisons were highly significant. They also compared negative right quarters to negative left quarters and found no difference.

The chloride-lactose number in milk is used as an expression of the ratio of chloride to lactose in milk. Chloride-lactose number = $\frac{100 \text{ x percent Cl}}{\text{Percent lactose}}$. This ratio falls in the range of 1.5 to 3.0 for normal milk but increases in milk from infected udders because the chloride content increases and the lactose decreases (8).

Vanlandinham _et al_. (16) studied the chloride and lactose content of normal and abnormal milk. The milk from quarters free from mastitis was found to contain an average of 0.12% chlorine, and an average of 4.788% lactose. The chlorine-lactose number averaged 2.614. Milk secreted by quarters with mastitis contained a higher percentage of chlorine and a lower percentage of lactose than milk from normal quarters. The chlorine-lactose number was higher in the milk from mastitic quarters than from normal quarters.

Ashworth _et al_. (3) also showed a definite relationship between the CMT reaction and the chloride level in milk. The average difference in chloride content of normal and mastitic milk varied from 1 mM/liter in the negative-trace comparison to 16 mM/liter in the negative-three comparison.

Marquardt (12) reported that the enzyme activity, namely catalase and A-esterase, increased in milk with a more severe CMT reaction.

Cecil _et al_. (5) compared milk from mastitic quarters with milk from normal quarters to determine the effect of mastitis on the glycogen level of the milk. The glycogen level of normal milk was relatively low, about 15 ug/ml, while that of abnormal milk was very high, 125 ug/ml. Since leucocytes have a high glycogen level, it was postulated that the increased glycogen was contributed by an infiltration of the leucocytes into the milk. A correlation of the leucocyte count with the glycogen level in milk showed that below 10 million leucocytes per milliliter of milk there appeared to be no correlation between the number of leucocytes and the glycogen level, but above this number there was a positive correlation. Therefore it was postulated that the increased cell count was responsible for the increased glycogen level.

In summary, there was a consistent inverse relationship between the mastitis reaction and the total solids, solids-not-fat, fat, and lactose content when comparing normal milk to mastitic milk. The greatest difference was found in the negative-three CMT comparison. Direct relationships existed between the CMT reaction and the pH, chloride, and total protein content of the compared milk samples. The increase in the total protein was shown to be in the whey protein fraction.

The addition of 1 to 20 percent of obviously abnormal milk to the cheese vat resulted in soft, mushy curds, loss of fat, retention of moisture, and a mature cheese with a mealy or pasty body and a distinct sour or bitter flavor. Inclusion of 10 to 25 percent abnormal milk normal in appearance had no significant influence on yield or quality of mature cheese. One hundred percent abnormal milk normal in appearance gave a weak coagulum that consequently resulted in loss of fat and retention of moisture. The yield of cheese from 100% abnormal milk that was normal in appearance was slightly lower than for normal milk due to the lower casein value and the higher fat loss (13, 14).

Cheesemakers have long known that abnormal milk yields cheese with a weak body and a poor texture. Davis and McClememost (6) found that milk obtained from infected cows yielded a cheese that was not much different in appearance than cheese obtained from milk produced by normal cows. More severe mastitis yielded cheese with a weaker body than normal.

EXPERIMENTAL PROCEDURE

All milk used for these experiments was obtained from the herd at the South Dakota State University Dairy Research and Production Unit. The milk was processed at the University dairy processing plant and the analytical work carried out in the laboratories of the Dairy Science Department.

Procurement of Milk

Abnormal milk for the first laboratory lots was chosen randomly from mastitic cows. Normal milk was taken from normal cows at the same milking. Smaller laboratory lots of milk were obtained from individual cows. Mastitic and normal quarters were milked separately and the milk was used for closer control of variables in the milk.

The larger amounts of abnormal milk were obtained from selected mastitic cows and the milk was pooled. The normal milk was mixed herd milk taken from the bulk storage tank at the University dairy processing plant.

Preparation of Milk

The laboratory lots of milk were pasteurized in a water bath at a temperature of 63 C for 30 minutes. The larger amounts of milk were pasteurized in a 100-gallon pasteurizing vat at a temperature of 63 C for 30 minutes. The milk was cooled and stored overnight at 4.4 C.

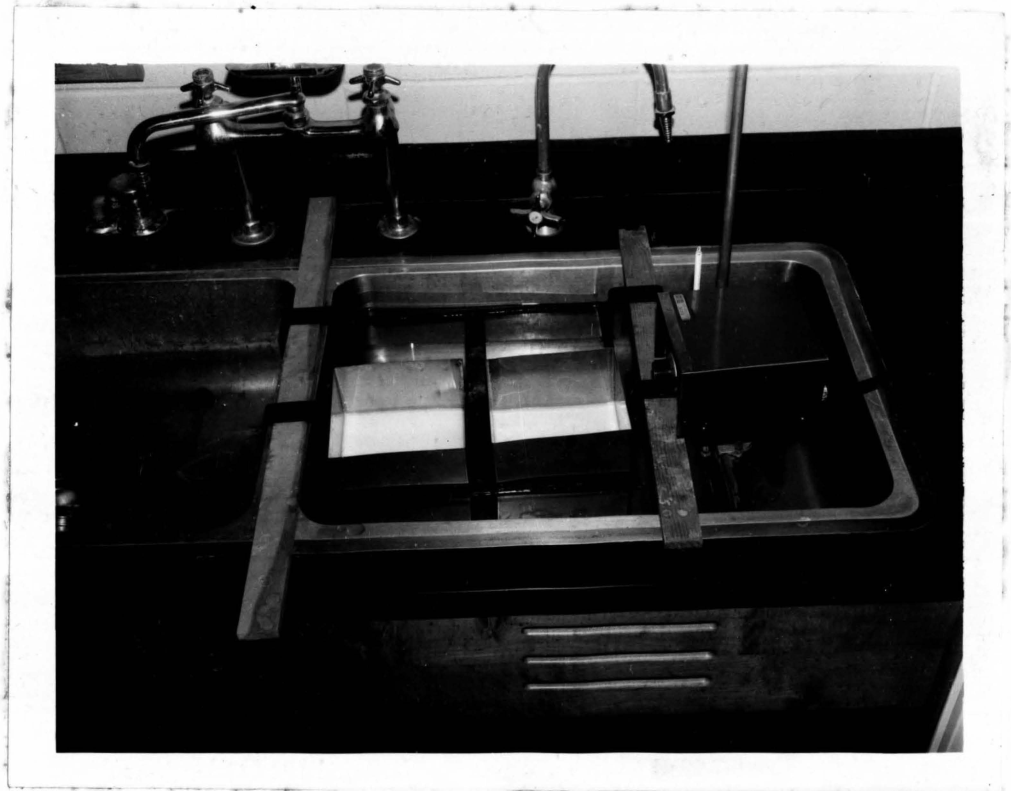

Fig. 1. One-gallon laboratory cheese vats

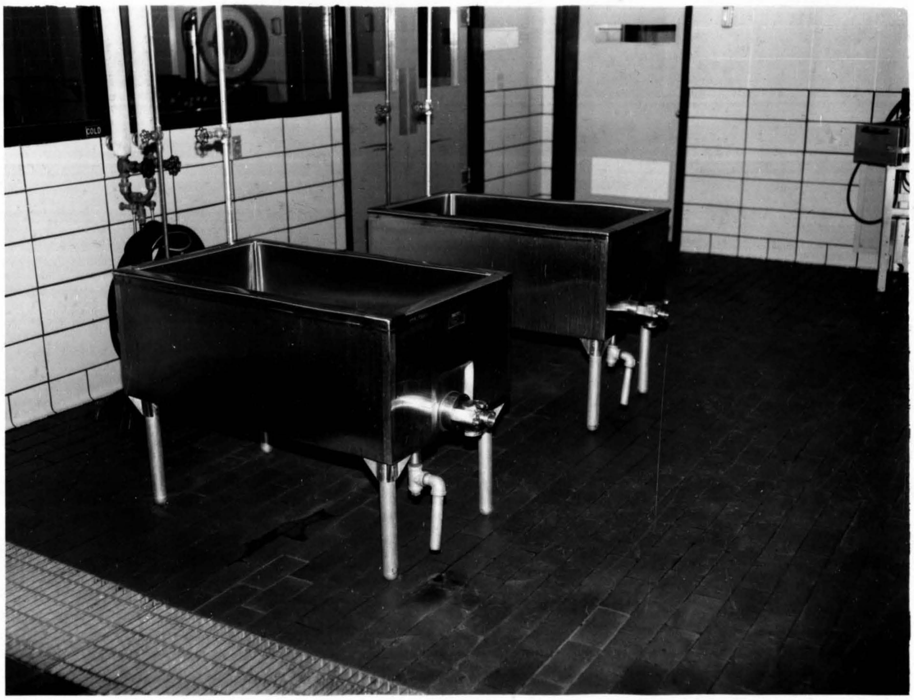

Fig. 2. Experimental cheese vats

Cheesemaking Procedure

The laboratory method of making the cheese consisted of using two one-gallon stainless steel vats as shown in Figure 1, with one containing normal milk as a control, and the other containing abnormal milk. The temperature was controlled by placing the vats in a water bath that was controlled by a precision built unit that heated and circulated the water around the vats. The amount of milk used in this procedure varied from 800 milliliters to 3000 milliliters. The regular cheesemaking operation was modified for the small vats. After the curd was drained it was weighed and a sample was taken for analysis. The procedure was ended here, because the amount of curd was so small that it was not practical to cheddar, mill, salt, and press the cheese. Because of this modified procedure the curd contained a large amount of moisture.

The larger vats of cheese were made in the University dairy processing plant. Two 40-gallon vats, as shown in Figure 2, were used with one vat containing the normal milk as a control and the other containing the mastitic milk. The cheese made from normal and abnormal milk was made simultaneously in both the large and small vats. The procedure used is outlined in Table 1.

After the pressing of the cheese from the large vats it was weighed, sampled, wrapped, and put in a curing room. The whey from the cheese from both procedures was collected, sampled, weighed, and was then discarded.

Table 1. Clock or time schedule for pasteurized milk cheddar cheese making

Steps in making	Minutes to next step	Temperature C	Acid	Comments
Add starter	30	30	0.16	0.70% strained
Add color	15	31.1	0.16	1 oz per 1000 lbs
Add rennet	12	31.1	0.165	3 oz per 1000 lbs
Coagulation	18	31.1	No test	Vat covered
Cut curd	15	31.1	0.10	1/4" knives
Steam on	30	31.1	0.10	Slowly by schedule
Steam off	60	39.0	0.105	Slow agitators
Settle curd	30	39.0	0.12	8"-10" deep
End dipping	15	39.0	0.14	18" trench
Pack	Turn curd	38.0	0.17	Blocks 7" wide
Pile two high	every	36.0	0.25	Cut blocks in half
Pile three high	15 minutes	34.0	0.30	Smooth ends
Mill	--	32.8	0.40	Smooth and silky
Salt	40	31.7	No test	2.5 lbs per 1000 lbs of milk
Hoop	20	31.1	No test	All salt dissolved
Press	30	31.1	No test	Full pressure after 15 minutes
Dress	--	--	No test	Well closed

Laboratory Analysis

A. The Kjeldahl determination of nitrogen (9) as outlined by The Official Methods of Analysis of the Association of Official Agricultural Chemists was performed on the normal and abnormal samples of milk, casein, cheese, and whey to determine the amount of nitrogen, calculated as protein, in the samples. Ten-gram samples were distilled into a 4.0% Boric acid solution and were titrated to the endpoint, using an indicator consisting of 0.5 gm methylene blue, 0.75 gm methyl red and 600 milliliters of ethanol with a known strength of sulfuric acid. The following formula was used to calculate the amount of nitrogen in the sample.

$$\frac{\text{ml } H_2SO_4\text{(sample)} - \text{ml } H_2SO_4\text{(blank)} \times \text{Normality acid} \times 0.14 \times 100}{\text{Sample weight}} = N$$

The percent protein in the sample equaled the percent nitrogen times 6.38.

B. Casein was determined in the normal and mastitic milk by precipitating the casein fraction with Glacial Acetic Acid as outlined in the AOAC official methods, (9). The nitrogen was determined by the Kjeldahl method and the result was multiplied by 6.38 to obtain the equivalent of casein.

C. The normal and abnormal milk was examined microscopically, by the Milk Industry Foundation method for the number of leucocytes present (7). The milk was stained with the Levowitz-Weber stain and was examined under a microscope with a microscopic factor of 570,000. This procedure was used as a measure of the degree of abnormality of the milk samples.

D. The Mojonnier test (15) for fat and total solids was performed on all samples of milk and whey. A ten-gram sample was used for the fat determination and approximately two grams were used for total solids determination.

E. Total moisture was determined on the normal and mastitic cheese by a modified method of the Milk Industry Foundation (7). The amount of moisture was determined by weighing exactly 10 grams of cheese into a covered moisture dish and placing the dish in a forced draft oven at 110 C for 16 hours. The dried dish and sample were weighed back and the percent moisture calculated from loss in weight.

Yield Calculations

All samples of milk used in these experiments were weighed before they were put in the cheese vats. The cheese and the whey were weighed after the cheesemaking procedure and these weights were used for yield calculations.

RESULTS AND DISCUSSION

Early workers producing cheese from abnormal milk concluded that abnormal milk made into cheese resulted in a weak body and a poor texture with little information regarding yield.

Because of the lack of information, this study was designed to analyze the milk before the cheesemaking operation and the whey and the cheese after the cheese was made. The milk was analyzed for fat and total solids by the Mojonnier method and for total nitrogen and casein by the Kjeldahl method. These results were converted to a dry weight basis and were compared to the cheese yields.

A leucocyte count was run on both the normal and abnormal milk used for the cheese. Table 2 shows the leucocyte ranges for the milk used.

Table 2. Leucocyte range for the normal and abnormal milk used for cheesemaking

Range	Small lots		Large lots	
	Normal	Abnormal	Normal	Abnormal
100,000 to 500,000	12	0	5	0
500,000 to 1,000,000	2	2	0	3
1-5 million	1	9	0	2
5-10 million	0	1	0	0
10-15 million	0	1	0	0
15-20 million	0	2	0	0

Most of the normal milk samples used for the control lots were in the range of 100,000 to 500,000 leucocytes per milliliter. The range did not vary appreciably between the large and small lots. The largest percentage of the leucocyte counts for the small lots were in the 1 million to 5 million range with a few on either side of this range and with two samples in the 15 million to 20 million range. The large lots were in a smaller range from 500,000 to 5 million. No correlation could be made between the leucocyte count and any of the yield calculations.

The yield from the abnormal and normal samples of milk was compared to the total pounds of milk used, total fat, total solids, total protein, and casein percent of total protein, to determine the degree that mastitis affected the yield. Table 3 shows the comparison of the normal and abnormal milk.

Table 3 also shows the yield based on the various milk constituents and also compares the small lots made in the laboratory with the large lots made in the processing plant. The results in Table 3 consist of 20 lots of normal cheese and 20 lots of mastitic cheese; fifteen of these lots were small lots and five were large lots.

The first comparison shows the relationship between the yield of cheese and the grams of milk used. The small and large lots of normal milk did not vary appreciably. The normal milk yielded 6.2936 grams of cheese per 100 grams of milk in the small lots and 6.2084 in the large lots. The abnormal milk yielded 6.3978 for the

Table 3. The comparison of yield of cheese of normal and abnormal milk samples based on various milk constituents

Yield of cheese based on	Small lots Grams of cheese*** Normal	Small lots Grams of cheese*** Abnormal	Large lots Grams of cheese*** Normal	Large lots Grams of cheese*** Abnormal
1. 100 grams of milk	6.2936	6.3978	6.2084	6.2470
2. Per gram of fat	2.1390	2.2974	1.8375	1.7941
3. Per gram of total solids	0.5264	0.5496	0.5240	0.5438
4. Per gram of total protein	1.9004	1.8141	1.9029	1.8862
5. Per gram of casein protein	2.5274	2.5436	2.4999	2.5356
6. Casein percent of total protein**	75.14*	71.35*	76.07*	75.46*

* Indicates percent casein of total protein.
** Not based on cheese yield.
*** Values are on dry weight basis.

large lots and 6.2470 for the small lots. The small lots of abnormal and normal milk yielded slightly more cheese because the cheese was not pressed after the draining operation. The pressing operation caused some fine particles to be lost. The large and small lots of abnormal milk had a slightly larger yield which was caused by a slightly higher total solids content in the original milk used.

The second comparison in Table 3 was between the grams of fat in the original milk and the yield of cheese. The small lots of normal milk yielded 2.1390 grams of cheese per gram of fat and the large lots yielded 1.8375. The small lots of abnormal milk yielded 2.2974 grams of cheese per gram of fat and the large lots yielded 1.7941. In both the normal and the abnormal milk the smaller lots produced a greater amount of cheese.

The pressing operation was performed only on the large lots. During this operation the fat loss was increased in the large lots. A Mojonnier test of the whey showed a fat loss in the normal whey of 0.3592% and 0.3864% in the abnormal lots. McDowall (13) showed that yield from abnormal milk was slightly lower than from normal milk because of a higher fat loss. The higher fat losses were caused by a weaker curd from the abnormal milk. Aside from the decreased yield due to high fat losses, the fat lost in the whey presents a problem to the cheese factory in the utilization of its by-products.

The third comparison in Table 3 shows the relationship between the yield of cheese and the total solids in the original milk. The small lots of normal cheese yielded 0.5264 grams of cheese per gram of total solids as compared to 0.5240 in the large normal lots. The small abnormal milk lots yielded 0.5496 grams of cheese and the large lots yielded 0.5438. There appeared to be no appreciable difference between the large and small lots in either the normal or abnormal milk. There appeared to be a greater loss of total solids in the whey from normal milk than there was in the whey from abnormal milk. No explanation could be given for this greater loss of total solids in the normal whey or in the higher yield from the abnormal lots.

The protein content of the milk is probably the most important constituent in calculating the yield of cheese. The abnormal milk had a higher average total protein, but had a lower casein protein. The average yield from the small lots was 1.9004 grams and 1.9029 from the large lots. The small abnormal milk lots yielded 1.8141 grams and the large lots yielded 1.8862 grams. There appeared to be no appreciable difference between the large and small lots of milk. This comparison was the only one in which the normal lots yielded more than the abnormal lots. The abnormal milk contained a larger percent of non-casein protein and apparently much of this fraction was lost in the whey. This agreed with Ashworth <u>et al</u>. (3) who reported that the whey proteins increased with the increase in the severity of mastitis reaction.

The fact that normal milk yielded more than the abnormal milk on a protein basis may be only of academic value, it is not of practical value to the cheese factory because most of the milk is bought on a fat or total solids basis with no regard to the total protein or casein protein.

There appeared to be no appreciable difference between the yield of cheese from the normal and abnormal milk when compared to the amount of casein in the milk. The small lots of normal milk yielded 2.5274 grams of cheese and the large lots of normal milk yielded 2.4999 grams. The small lots of abnormal milk yielded 2.5436 grams of cheese and the large lots yielded 2.5356. No difference was expected because casein is the principal constituent of milk that determines cheese yields and there has been no research to indicate that mastitis affects the composition of the casein. It was assumed that the mastitic and normal casein was of similar composition and would yield approximately the same amount of cheese per gram of casein.

As was stated earlier mastitis caused a reduced casein level in the milk and an increased whey protein level. As shown in Table 2 the percent casein of total protein was lower in the mastitic milk than in the normal. The small lots of normal milk contained 75.14 casein percent of total protein and the large lots of normal milk contained 76.07. The small lots of abnormal milk contained 71.35 percent and the large lots contained 75.46 percent. The small mastitic lots were obtained from individual infected quarters and were not diluted as the large lots were. Ashworth (1) reported a wide range in the percent casein of total protein values. His results varied from 60.2 percent in milk with a CMT reaction of two to 77.0 percent with a CMT reaction of trace.

It was expected that a higher casein content in the normal milk used for cheesemaking would have yielded more cheese, but there was no increased yield in the lots of cheese that were produced in this study. The differences caused by the abnormal milk may not have been great enough to be measured by the methods used in this study.

McDowall (13) reported that 1 to 25 percent mastitic milk had no effect on the yield of cheese. He reported, however, that 100 percent mastitic milk yielded slightly less cheese due to the lower casein content and to the higher fat loss.

SUMMARY AND CONCLUSIONS

Previous studies on mastitis have concerned mainly the control of the disease or the changes that occur in the composition of the milk. Ashworth et al. (3) found that there was a consistent inverse relationship between the mastitis reaction and the total solids, solids-not-fat, fat and lactose content when comparing mastitis to normal milk.

Since very little work has been done on comparing the yield of cheese with the degree of mastitis, this study was conducted to analyze the milk, cheese and whey and compare the yield of cheese from normal and abnormal milk on the basis of fat, total solids, protein and casein contents on a dry weight basis. The leucocyte count was used as a basis for the severity of the mastitis. No appreciable differences were noticed in any of the comparisons. The largest difference in which the normal milk lots yielded more than the abnormal milk lots was in the total protein comparison when it was related to the cheese yield. It was postulated that the decreased casein content and the increased whey protein content caused the difference. The casein percent of the total protein was 75.37% for the normal milk and 72.38% for the abnormal milk.

From the results of this study it was postulated that mastitis does not measurably affect the yield of cheese except in severe cases. Possibly the greatest effect on the cheese factory would be from the aesthetic standpoint.

Realistic studies comparing normal and abnormal milk for cheesemaking are difficult to conduct because of the difficulty in obtaining different ranges of mastitic milk. Small lots of milk can be made into cheese in the laboratory and satisfactory results can be made in most cases, however it was not practical to cheddar or press the curd after it is drained. Without the last steps in the cheesemaking operation, nothing can be determined about the effect on body, texture, and flavor.

Further study is needed in relating cheese yields to mastitis. Analysis of the casein for changes in composition as a result of mastitis might be beneficial to the study and strict analytical methods must be used to show differences that may have been too small to have been detected in this study.

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APPENDIX

Table 4. Relationships between the cheese yield and total pounds milk, fat, and total solids in normal and abnormal milk*

Trial	100 grams milk*		Fat*		Total solids*	
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal
1.	7.4620	8.5530	1.8110	1.6464	0.5764	0.6087
2.	7.8303	7.0650	1.5130	1.6596	0.5421	0.5442
3.	7.2810	9.0510	1.5615	1.6478	0.5317	0.6185
4.	6.1529	6.3641	2.0173	2.2075	0.5203	0.5548
5.	6.0960	5.7350	2.3064	2.4178	0.5372	0.5372
6.	6.9440	6.3933	2.7485	3.1681	0.6217	0.6231
7.	7.4785	5.4038	2.0557	2.5794	0.5706	0.5213
8.	6.8130	5.5350	2.3260	2.2797	0.5739	0.5327
9.	5.6246	5.1506	2.0633	2.3087	0.4978	0.4933
10.	5.1300	7.2960	L. A.	2.3027	0.4809	0.6000
11.	6.0150	6.4750	2.0040	2.3220	0.5223	0.5692
12.	5.7760	6.3190	3.0068	2.5771	0.5536	0.5789
13.	6.4460	5.3450	2.2359	2.8552	0.5732	0.5360
14.	3.5940	4.4550	2.3398	2.7534	0.3843	0.4545
15.	5.7600	7.0260	1.9567	1.7354	0.4094	0.4873
16.	5.9362	5.9449	1.8887	1.8639	0.5096	0.5213
17.	5.0411	6.1111	2.2545	1.8086	0.4714	0.5147
18.	5.3672	6.0991	1.7574	1.8426	0.4953	0.5257
19.	8.5868	6.4668	1.4994	1.7478	0.5990	0.5356
20.	6.111	6.6135	1.7874	1.7076	0.5090	0.5356

* Values are grams of cheese per 100 grams of milk, per gram of fat or per gram of total solids.

Table 5. Relationships between the cheese yield and total protein*, casein protein* and casein percent of total protein** in normal and abnormal milk

Trial	Total Protein		Casein Protein		Casein % of T. P.	
	Normal	Abnormal	Normal	Abnormal	Normal	Abnormal
1.	1.9962	2.0143	2.7440	2.5490	72.74	79.00
2.	1.9176	1.5282	2.8150	2.2750	68.10	67.16
3.	2.1378	2.2801	2.6140	2.9190	81.78	78.09
4.	2.0798	1.7743	2.8285	2.6791	73.53	66.22
5.	1.9264	1.5759	2.4860	2.1180	77.49	77.41
6.	2.2813	2.0854	3.0323	2.9362	75.23	71.02
7.	2.0859	1.5789	2.6473	2.3032	78.80	68.55
8.	1.9103	1.7380	2.4889	2.4539	76.76	70.83
9.	1.8179	1.6317	2.3877	2.2558	76.14	72.35
10.	1.3408	1.8915	1.8719	2.6900	71.63	70.32
11.	2.1198	2.1185	2.8192	3.1892	71.67	66.42
12.	1.9367	1.9885	2.5906	2.7075	74.76	73.44
13.	2.2328	1.8457	3.1011	2.6277	72.00	70.24
14.	1.2976	1.4773	1.6380	2.0401	79.23	72.41
15.	1.4251	1.6829	1.8461	2.4107	77.20	69.81
16.	1.8526	1.8376	2.3929	2.4970	77.42	78.74
17.	1.5774	1.8614	2.0862	2.5567	75.61	72.80
18.	1.8253	1.8810	2.4167	2.5244	75.53	74.52
19.	2.5304	1.9519	3.3110	2.6667	76.42	73.19
20.	1.7286	1.8002	2.2931	2.4333	75.38	78.05

* Values are grams of cheese per gram of total protein or per gram of casein protein. ** Value is percent of total protein.